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## (54) Optical fiber and optical transmission line

(57) The optical fiber includes a center core portion (1), a side core portion (2) and clad portion (3) in an order from an inner side, which has a dispersion value of 14 ps/nm/km or higher and 20 ps/nm/km or less at a wavelength of 1550 nm, a dispersion slope of 0.05 ps/nm<sup>2</sup>/km or higher and 0.08 ps/nm<sup>2</sup>/km or less at a wavelength of 1550 nm and a transmission attenuation of 0.2 dB/km or less at a wavelength of 1550 nm, wherein the relative refractive index difference  $\Delta 1$  between the center core portion (1) and the side core portion (2) is 0.25% or larger and 0.50% or less, the relative refractive index difference  $\Delta 2$  between the side core portion (2) and the clad portion (3) is 0.05% or larger and 0.30% or less, an inequality  $\Delta 2 < \Delta 1$  is satisfied, the ratio  $a/b$  between an outer diameter  $a$  of the center core portion (1) and an outer diameter  $b$  of the side core portion (2) is 0.3 or higher and 0.7 or less, and the effective core area  $A_{eff}$  at a wavelength of 1550 nm is 90  $\mu\text{m}^2$  or larger.

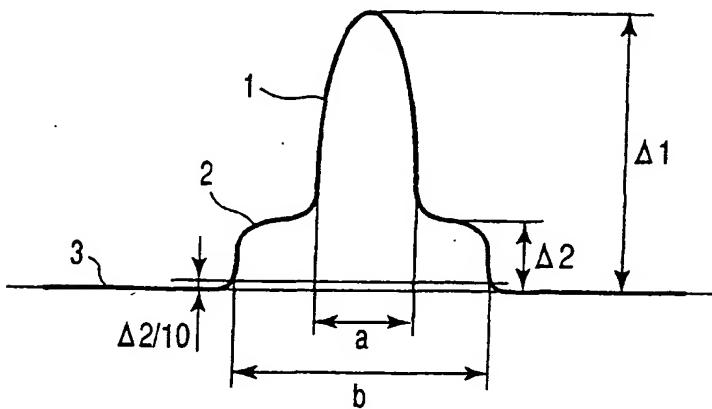


FIG. 1

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**Description**

[0001] The present invention relates to an optical fiber and an optical transmission line used suitably in a wavelength division multiplexing (WDM) optical communications.

5 [0002] As a technique for increasing the transmission capacity in the optical transmission using optical fibers, the WDM (wavelength division multiplexing) optical transmission has become a focus of attention recently, and many intensive studies have been conducted on optical fibers which are employed suitable in the WDM optical transmission.

[0003] Incidentally, well-known examples of the optical fiber which can be used for the WDM optical transmission are a single mode optical fiber (SMF) having a zero dispersion near a wavelength of 1.3  $\mu\text{m}$  and a dispersion shift type 10 optical fiber which does not have a zero dispersion in a wavelength band in use (NZDSF); however these types of optical fibers have a problem of non-linearity. Under these circumstances, there is a demand of developing a new type of optical fiber.

[0004] More specifically, in order to solve the problem of non-linearity, an optical fiber has been developed, in which the dispersion value is set fully away from zero and the effective core area  $A_{\text{eff}}$  is enlarged. Examples of such an 15 optical fiber is discussed in Collection of Lecture Notes C-3-76 and C-3-77 for the Electronics Society Convention 1999 held by the Institute of Electronics, Information and Communication Engineers.

[0005] However, those types of optical fibers discussed in Lecture Notes C-3-76 and C-3-77, each exhibits a dispersion value of more than 20 ps/nm/km, and therefore the cumulative amount of dispersions of fibers when an optical 20 transmission line is formed of these fibers, increases. With such an increased amount of dispersion, the transmission line cannot be appropriately used for a long-distance WDM optical transmission.

[0006] An object of the present invention is to provide an optical fiber which has a dispersion value maintained at a similar level to that of the conventional SMF and is more suitable for the WDM optical transmission than the conventional SMF.

[0007] Another object of the present invention is to provide an optical transmission line comprising the above-described 25 optical fiber, which is suitable for the WDM optical transmission.

[0008] According to an embodiment of the present invention, there is provided an optical fiber comprising a center core portion, a side core portion and a clad portion in an order from an inner side, which has a dispersion value of 14 ps/nm/km or higher and 20 ps/nm/km or less at a wavelength of 1550 nm, a dispersion slope of 0.05 ps/nm<sup>2</sup>/km or higher and 0.08 ps/nm<sup>2</sup>/km or less at a wavelength of 1550 nm and a transmission attenuation of 0.2 dB/km or less at 30 a wavelength of 1550 nm, wherein a relative refractive index difference  $\Delta_1$  between the center core portion and the clad portion is 0.25% or larger and 0.50% or less, a relative refractive index difference  $\Delta_2$  between the side core portion and the clad portion is 0.05% or larger and 0.30% or less, an inequality  $\Delta_2 < \Delta_1$  is satisfied, a ratio  $a/b$  between an outer diameter  $a$  of the center core portion and an outer diameter  $b$  of the side core portion is 0.3 or higher and 0.7 or less, and an effective core area  $A_{\text{eff}}$  at a wavelength of 1550 nm is 90  $\mu\text{m}^2$  or larger.

[0009] According to another embodiment of the present invention, there is provided an optical transmission line comprising a plurality of optical fibers, configured to transmit optical signals, wherein at least one of the plurality of optical fibers is the above-described optical fiber.

[0010] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

40 [0011] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagram schematically showing an example of the refractive index profile of an optical fiber according to an embodiment of the present invention; and

45 FIG. 2 is a diagram schematically showing an optical transmission system comprising an optical fiber according to the embodiment of the present invention.

[0012] Specific embodiments of the present invention will now be described with reference to accompanying drawings.

50 [0013] FIG. 1 is a diagram schematically showing an example of the refractive index profile of an optical fiber according to an embodiment of the present invention. FIG. 1 illustrates a refractive index profile 1 of a center core portion having an outer diameter  $a$ , a refractive index profile 2 of a side core portion having an outer diameter  $b$ , and a refractive index profile 3 of a clad portion.

[0014] As can be seen in FIG. 1, there is a maximum relative refractive index difference  $\Delta_1$  between the center core portion 1 and the clad portion 3, and there is a relative refractive index difference  $\Delta_2$  between the side core portion 2 and the clad portion 3.

[0015] It should be noted here that with regard to the optical fiber according to the embodiment, the relative refractive index difference  $\Delta_2$  between the side core portion 2 and the clad portion 3 is defined as follows.

[0016] That is:

- (1) In the case where there is no local maximum point of the refractive index in the side core portion 2, the relative refractive index difference  $\Delta 2$  is taken by the value where the slope of the refractive index profile curve is at minimum.
- (2) In the case where there is a local maximum point of the refractive index in the side core portion 2, the relative refractive index difference  $\Delta 2$  is taken by the value of the relative refractive index difference between the local maximum point of the refractive index in the side core portion and the clad portion 3. Or in the case where there are a plurality of local maximum points of the refractive index, it is taken by the value of the relative refractive index difference between the maximum value of the local maximum points of the refractive index in the side core portion 2 and the clad portion 3. It should be noted here that there is a local minimum point when there is a local maximum point of the refractive index in the side core portion 2. Here, when the local minimum value of the relative refractive index differences (that is, the local minimum values of the refractive index) between the side core portion 2 and the clad portion 3 is 0.5 times or more as large as  $\Delta 2$ , the side core portion 2 is formed as one region.

[0017] Further, the border between the center core portion 1 and the side core portion 2 is defined at a point where when the curve of the refractive index profile of the center core portion 1 is approximated by an  $\alpha$  curve, the  $\alpha$  curve crosses with the line of the relative refractive index difference being zero. It should be noted that the  $\alpha$  curve can be expressed by the following formula:

$$\Delta n(r) = \Delta n(0) \cdot \{1 - (2r/a)^\alpha\}$$

where  $\Delta n(r)$  represents the relative refractive index difference at a distance "r" from the center,  $\Delta n(0)$  represents the maximum relative refractive index difference, "a" represents the outer diameter of the center core portion and "r" represents the distance from the center.

[0018] Further, the border between the side core portion and the clad portion is defined at a point where the relative refractive index difference becomes 1/10 of the relative refractive index difference  $\Delta 2$  between the side core portion and the clad portion, and a line extending in the direction where the relative refractive index difference changes crosses with the line of the relative refractive index difference being zero.

[0019] In the refractive index profile of the optical fiber according to the embodiment shown in FIG. 1, the relative refractive index difference  $\Delta 1$  between the center core portion and the clad portion is 0.25% to 0.50%, and more preferably, it should be in a range of 0.33% to 0.40%. If the relative refractive index difference  $\Delta 1$  is less than 0.25%, the dispersion value rises to 20 ps/nm/km or more, whereas if it exceeds 0.50%,  $A_{eff}$  drops to 90  $\mu\text{m}^2$  or less, which is not preferable.

[0020] The relative refractive index difference  $\Delta 2$  between the side core portion and the clad portion is 0.05% to 0.30%, and more preferably, it should be in a range of 0.15% to 0.20%. If the relative refractive index difference  $\Delta 2$  is less than 0.05%, bending attenuation becomes large, whereas if it exceeds 0.30%, cut-off wavelength exceeds 1550 nm, which is not preferable.

[0021] The relationship between  $\Delta 1$  and  $\Delta 2$  should be  $\Delta 2 < \Delta 1$ , and if  $\Delta 2 \geq \Delta 1$ , desired properties are not obtained, which is not preferable.

[0022] In the optical fiber having a refractive index profile as described above, the ratio  $a/b$  between the outer diameter  $a$  of the center core portion and the outer diameter "b" of the side core portion should be in a range of 0.3 to 0.7, and more preferably it should be in range of 0.4 to 0.6. If the  $a/b$  ratio is less than 0.3, cut-off wavelength becomes large, whereas if it exceeds 0.7, bending attenuation becomes large, which is not preferable.

[0023] The effective core area  $A_{eff}$  at a wavelength of 1550 nm should be 90  $\mu\text{m}^2$  or more, and more preferably it should be 100  $\mu\text{m}^2$  or more. If the effective core area  $A_{eff}$  at a wavelength of 1550 nm is less than 90  $\mu\text{m}^2$ , non-linear effect becomes prominent.

[0024] In the optical fiber according to the embodiment described above, the dispersion value at a wavelength of 1550 nm should be in a range of 14 ps/nm/km to 20 ps/nm/km, and more preferably it should be in a range of 14 ps/nm/km to 16 ps/nm/km. If it is tried to attain the dispersion value less than 14 ps/nm/km at a wavelength of 1550 nm, refractive index profile becomes complicate and productivity becomes worse, whereas if it exceeds 20 ps/nm/km, waveform is distorted, which is not preferable.

[0025] The dispersion slope at a wavelength of 1550 nm should be in a range of 0.05 ps/nm<sup>2</sup>/km to 0.08 ps/nm<sup>2</sup>/km, and more preferably it should be in a range of 0.05 ps/nm<sup>2</sup>/km to 0.07 ps/nm<sup>2</sup>/km. If it is tried to attain the dispersion slope less than 0.05 ps/nm<sup>2</sup>/km at a wavelength of 1550 nm, refractive index profile becomes complicate and productivity becomes worse, whereas if it exceeds 0.08 ps/nm<sup>2</sup>/km, transmission wavelength intervals must be widened, which is not preferable.

[0026] The transmission attenuation at a wavelength of 1550 nm should be 0.2 dB/km or less, and more preferably it should be 0.19 dB/km or less. If the transmission attenuation at a wavelength of 1550 nm exceeds 0.2 dB/km, distance between amplifiers becomes short, which is not preferable.

5 [0027] In order to achieve an optical fiber suitable for WDM optical transmission, it is necessary that the waveform distortion due to the four wave mixing should be suppressed, the distortion of the waveform due to the self phase modulation/cross-phase modulation should be suppressed and the distortion of the waveform due to dispersion should be suppressed.

10 [0028] The optical fiber according to the embodiment, which satisfies the above-described conditions, meets the above-described requirement and it is very much suitable for the WDM optical transmission. With use of the optical fiber, it is possible to obtain an optical transmission line suitable for the WDM optical transmission.

15 [0029] FIG. 2 is a diagram illustrating an optical transmission system including an optical transmission line with the optical fiber according to the embodiment of the present invention. FIG. 2 shows an optical transmitter 11, optical amplifiers 12a, 12b, ..., positive dispersion optical fibers 13a, 13b, ..., negative dispersion optical fibers 14a, 14b, ..., such as DCFs, and an optical receiver 15.

20 [0030] The structure itself of the system shown in FIG. 2 is similar to that of the conventional system; however, a part of the system, specifically, optical fibers 13a, 13b, ..., are of the fibers according to the embodiment of the present invention. With this structure, it becomes possible to remarkably improve the transmission properties. And then, it is possible to obtain an optical transmission line suitable for the WDM optical transmission.

25 [0031] Examples of the present invention will now be presented, and the invention will be explained in more detail.

#### Examples

30 [0032] The optical fiber having the refractive index profile shown in FIG. 1, was examined in terms of the change in properties at a wavelength of 1550 nm, when the parameters ( $\Delta 1$ ,  $\Delta 2$ ,  $a/b$ ) were varied. It should be noted that the refractive index of the center core portion 1 was set such that it could be approximated with a curve of  $\alpha = 2$  and the side core portion had no maximum points of the refractive index.

35 [0033] The outer diameter "b" of the side core portion 2 can be set in a range of 10 to 40  $\mu\text{m}$ , and preferably it should be in a range of 18 to 30  $\mu\text{m}$ . In this embodiment, the outer diameter "b" of the side core portion 2 was set to an optimal value within a range of 18 to 30  $\mu\text{m}$ . It should be noted that the outer diameter "a" of the center core portion should preferably be in a range of 8 to 12  $\mu\text{m}$ .

40 [0034] The results of the examination are presented in TABLE 1 below. In TABLE 1, the units for the values of  $\Delta 1$  and  $\Delta 2$  are in %, the unit for the dispersion value is in ps/nm/km, the unit for the dispersion slope is in ps/nm<sup>2</sup>/km, the unit for the transmission attenuation is in dB/km, the unit for  $A_{\text{eff}}$  is in  $\mu\text{m}^2$ . For reference, a cutoff wavelength  $\lambda_c$  (unit in nm) is presented as well in the table.

TABLE 1

	$\Delta 1$	$\Delta 2$	$a/b$	Dispersion value	Dispersion slope	Transmission attenuation	$A_{\text{eff}}$	$\lambda_c$
Example 1	0.37	0.07	0.50	17.1	0.063	0.186	102	1320
Example 2	0.36	0.05	0.43	17.0	0.062	0.184	97	1260
Example 3	0.38	0.10	0.57	16.9	0.064	0.190	103	1460
Comparative Example	0.26	0.00	-	21.9	0.068	0.195	133	1580

45 [0035] As can be understood from TABLE 1 above, the optical fibers of Examples 1 to 3 each have a refractive index profile which is within the range defined by the present invention, and therefore they have the properties (the dispersion value is 20 ps/nm/km or less) suitable for the WDM optical transmission. By contrast, the optical fiber according to the comparative example has a refractive index profile which is out of the range defined by the present invention, and therefore its dispersion value exceeds 20 ps/nm/km. Further, its cutoff wavelength shifts to long wavelength side. Therefore, it is not suitable for the WDM optical transmission at a wavelength of near 1550 nm.

50 [0036] In the meantime, an optical transmission line was made of optical fibers according to Example 1 and line-type dispersion compensation optical fibers having such a length at which the dispersion can be substantially perfectly compensated. Of the optical fibers according to Examples 2 and 3 as well as that of Comparative Example, similar optical transmission lines were built. Then, the transmission test was carried out on these lines under conditions that an optical signal having 10 Gbps per wave was used as the WDM optical signal and 16 waves were arranged at the same intervals in a range of 1530 to 1560 nm in wavelength.

[0037] As a result, it was found that the optical transmission lines which were made of the optical fibers according to Examples 1 to 3 exhibited properties such as bit error rate of  $10^{-9}$  or less, which are suitable for the WDM optical transmission, whereas the optical transmission line made of the optical fiber according to the Comparative Example exhibited bit error rate exceeding  $10^{-9}$  and did not show suitable properties for the WDM optical transmission.

[0038] It should be noted here that the optical transmission line of the present invention is not limited to that discussed above, but can be remodeled into various versions. For example, the optical transmission line can be made of a dispersion compensation type fiber module in place of the line-type dispersion compensation optical fiber.

10 **Claims**

1. An optical fiber comprising: a center core portion (1), a side core portion (2) and clad portion (3) in an order from an inner side, which has a dispersion value of 14 ps/nm/km or higher and 20 ps/nm/km or less at a wavelength of 1550 nm, a dispersion slope of 0.05 ps/nm<sup>2</sup>/km or higher and 0.08 ps/nm<sup>2</sup>/km or less at a wavelength of 1550 nm and a transmission attenuation of 0.2 dB/km or less at a wavelength of 1550 nm,  
 characterized in that a relative refractive index difference  $\Delta 1$  between the center core portion (1) and the clad portion (3) is 0.25% or larger and 0.50% or less, a relative refractive index difference  $\Delta 2$  between the side core portion (2) and the clad portion (3) is 0.05% or larger and 0.30% or less, an inequality  $\Delta 2 < \Delta 1$  is satisfied, a ratio  $a/b$  between an outer diameter  $a$  of the center core portion (1) and an outer diameter  $b$  of the side core portion (2) is 0.3 or higher and 0.7 or less, and an effective core area  $A_{eff}$  at a wavelength of 1550 nm is 90  $\mu\text{m}^2$  or larger.
2. An optical fiber according to claim 1, characterized in that the relative refractive index difference  $\Delta 1$  is in a range of 0.33% to 0.4%, the  $\Delta 2$  is in a range of 0.15% to 0.2%, the ratio  $a/b$  between the outer diameter  $a$  of the center core portion (1) and the outer diameter  $b$  of the side core portion (2) is in range of 0.4 to 0.6, and the effective core area  $A_{eff}$  at a wavelength of 1550 nm is 100  $\mu\text{m}^2$  or larger.
3. An optical fiber according to claim 1, characterized in that the outer diameter  $b$  of the side core portion (2) is in a range of 10 to 40  $\mu\text{m}$ .
4. An optical transmission line comprising a plurality of optical fibers, configured to transmit an optical signal, characterized in that at least one of said plurality of optical fibers is an optical fiber according to claim 1.

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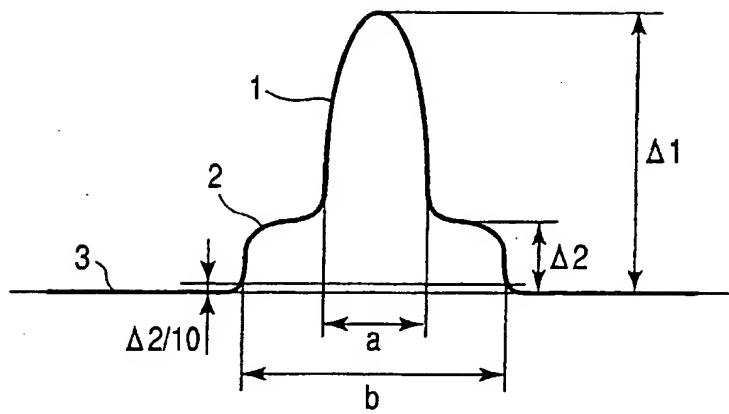


FIG. 1

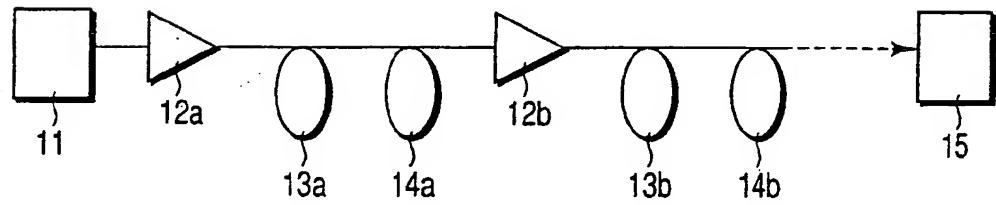


FIG. 2

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core portion (1) and the clad portion (3) is 0.25% or larger and 0.50% or less, the relative refractive index difference  $\Delta 2$  between the side core portion (2) and the clad portion (3) is 0.05% or larger and 0.30% or less, an inequality  $\Delta 2 < \Delta 1$  is satisfied, the ratio  $a/b$  between an outer diameter  $a$  of the center core portion (1) and an outer diameter  $b$  of the side core portion (2) is 0.3 or higher and 0.7 or less, and the effective core area  $A_{eff}$  at a wavelength of 1550 nm is 90  $\mu\text{m}^2$  or larger.

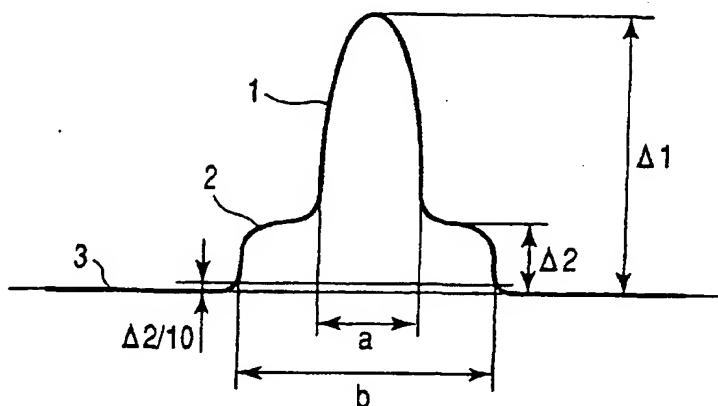


FIG. 1

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Application Number

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 01/001179 A (MUKASA KAZUNORI ;FURUKAWA ELECTRIC CO LTD (JP)) 4 January 2001 (2001-01-04) * figure 2E; example 7; table 6 * -& EP 1 116 970 A (FURUKAWA) 18 July 2001 (2001-07-18)	1-4	G02B6/22 G02B6/18 G02B6/16
Y	WO 00/62106 A (HIRANO MASAAKI ;KATO TAKATOSHI (JP); SUMITOMO ELECTRIC INDUSTRIES) 19 October 2000 (2000-10-19) * sample 1** figures 1B,2B,3 *	1-4	
Y	-& EP 1 107 027 A (SUMITOMO ELECTRIC INDUSTRIES) 13 June 2001 (2001-06-13)		
Y	US 4 755 022 A (UESUGI NAOSHI ET AL) 5 July 1988 (1988-07-05) * abstract; claim 1; figures 2-4 *	1-4	
Y	EP 0 307 228 A (CORNING GLASS WORKS) 15 March 1989 (1989-03-15) * page 7, line 9 - line 16; claim 6; figure 10 *	1-3	
Y	EP 0 779 524 A (CORNING INC) 18 June 1997 (1997-06-18) * page 4, line 28 - line 30; figures 1-4; table 1 *	1-3	
A	US 4 204 745 A (KIMURA TATSUYA ET AL) 27 May 1980 (1980-05-27) * column 4, line 2 - line 14; figures 1,2,4 *	1-3	
		-/-	
<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
Munich	19 March 2004	Blau, G	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	<p>LIU Y ET AL: "DESIGN AND FABRICATION OF LOCALLY DISPERSION-FLATTENED LARGE EFFECTIVE AREA FIBERS"          PROCEEDINGS OF THE EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION, XX, XX,          vol. 1, 20 September 1998 (1998-09-20),          pages 37-38, XP000879650          * figure 1; table 1 *</p> <p>-----</p>	1-3	
TECHNICAL FIELDS SEARCHED (Int.Cl.7)			
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
Munich	19 March 2004	Blau, G	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-03-2004

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
WO 0101179	A	04-01-2001		CA 2340947 A1 EP 1116970 A1 WO 0101179 A1 US 2002012509 A1	04-01-2001 18-07-2001 04-01-2001 31-01-2002
EP 1116970	A	18-07-2001		CA 2340947 A1 EP 1116970 A1 US 2002012509 A1 WO 0101179 A1	04-01-2001 18-07-2001 31-01-2002 04-01-2001
WO 0062106	A	19-10-2000		AU 3678400 A CA 2334888 A1 EP 1107027 A1 WO 0062106 A1 US 2001017967 A1	14-11-2000 19-10-2000 13-06-2001 19-10-2000 30-08-2001
EP 1107027	A	13-06-2001		AU 3678400 A CA 2334888 A1 EP 1107027 A1 US 2001017967 A1 WO 0062106 A1	14-11-2000 19-10-2000 13-06-2001 30-08-2001 19-10-2000
US 4755022	A	05-07-1988		JP 1657068 C JP 3018161 B JP 62052508 A CA 1269262 A1 FR 2586823 A1 GB 2185331 A ,B	13-04-1992 11-03-1991 07-03-1987 22-05-1990 06-03-1987 15-07-1987
EP 0307228	A	15-03-1989		US 4877304 A AT 117094 T AU 2207888 A CA 1311382 C DE 3852737 D1 DE 3852737 T2 EP 0307228 A2 JP 1163707 A JP 2885405 B2 US 4889404 A	31-10-1989 15-01-1995 09-03-1989 15-12-1992 23-02-1995 31-08-1995 15-03-1989 28-06-1989 26-04-1999 26-12-1989
EP 0779524	A	18-06-1997		US 5715346 A AU 721088 B2 AU 7417996 A BR 9605852 A CA 2192425 A1 CN 1160214 A ,B	03-02-1998 22-06-2000 19-06-1997 25-08-1998 16-06-1997 24-09-1997

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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ON EUROPEAN PATENT APPLICATION NO.**

EP 02 25 1047

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19-03-2004

Patent document cited in search report	Publication date		Patent family member(s)	Publication date
EP 0779524	A		DE 69620558 D1	16-05-2002
			DE 69620558 T2	10-10-2002
			DK 779524 T3	29-07-2002
			EP 1160595 A2	05-12-2001
			EP 0779524 A2	18-06-1997
			JP 3223474 B2	29-10-2001
			JP 9274118 A	21-10-1997
			RU 2166782 C2	10-05-2001
<hr/>				
US 4204745	A	27-05-1980	JP 1081620 C	29-01-1982
			JP 54003553 A	11-01-1979
			JP 56025647 B	13-06-1981
			DE 2825412 A1	14-12-1978
			FR 2394100 A1	05-01-1979
			GB 1589006 A	07-05-1981
<hr/>				

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82